PROJECTION TYPE DISPLAY DEVICE

This application claims the benefit of Japanese

5   Patent application No. 2001-062115 which is hereby

incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

10   The present invention relates to a projection

type display device constructed in a way that

modulates and reflects color beams entering

reflection type light valves disposed for a R (Red)-

beam, a G (Green)-beam and a B (Blue)-beam and lets

15   these beams exit, synthesizes and analyzes these

color beams, and projects the color beam through a

projection lens.

Related Background Art

An example of a construction of a prior art

20   projection type display device will be explained. To

begin with, a substantially parallel beam from a

light source is polarization-split by a polarization

beam splitter. Next, the thus polarization-split

beam is color-separated into the R (Red)-beam, the G

25   (Green)-beam and the B (Blue)-beam by a color

separating optical system. The color-separated color

beams such as the R-beam, G-beam and B-beam enter the

light valves for the R-, G- and B-beams. The
respective color light valves modulate the incidence
beams in accordance with image signals and let the
modulated beams exit. The reflected beams modulated
5   by the light valves are color-synthesized by a color
synthesizing optical system. Then, the color-
synthesized beam reenter the polarization beam
splitter and is analyzed. Finally, the analyzed beam
exiting the polarization beam splitter is projected
10   as a full-color image of the modulated image on a
screen through a projection lens.

FIG. 11 is a view schematically showing a
configuration of the projection type display device
in the prior art and light paths therein. A light
15   source 1 constructed of a lamp and a concave surface
mirror such as a parabolic mirror, emits
substantially parallel light source beam. The light
source beam from the light source 1 enters a fly's
eye integrator FE. The fly's eye integrator FE is
20   constructed of a first lens plate 2 having a
plurality of first lens elements 2a, 2b, 2c, and a
second lens plate 3 having a plurality of second lens
elements 3a, 3b, 3c corresponding to the first lens
elements 2a, 2b, 2c. Herein, the second element
25   elements 3a, 3b, 3c are provided in focal positions
of the first lens elements 2a, 2b, 2c. With this
construction, the beam from the light source 1 is,

after being split, overlapped on the light receiving surfaces of light valves defined as the radiation receiving surfaces. A uniformity of illuminance of the illumination radiation can be thereby enhanced.

5   The beams exiting the fly's eye integrator FE enter the polarization beam splitter 6 via a condenser lens 4 and a field lens 5. A polarized light splitting element 6P of the polarization beam splitter 6 reflects an S-polarized beam and transmits
10   a P-polarized beam, thus polarization-splitting the beams. The S-polarized beam reflected by the polarized light splitting element 6P is discarded as an unnecessary beam.

       The P-polarized beam exiting the polarization
15   beam splitter 6 enters a color separating/synthesizing composite prism constructed of prisms 7, 8 and 9. The color separating/synthesizing composite prism color-separates the light source beam into the B-, R and G-
20   beams. The structure for the color separation is the same as what is disclosed in, e.g., Patent Publication No.2505758, and therefore its repetitive explanation is herein omitted.

       The color-separated beams assuming the
25   respective colors are incident on light valves 10B, 10R, 10G for the respective colors. The color light valves 10B, 10R, 10G modulate the incidence beams in

accordance with image data and then let the modulated beams exit. The beams exiting the color light valves 10B, 10R, 10G enter the color separating/synthesizing composite prism and are color-synthesized. The thus

5 color-synthesized beam enters the polarization beam splitter 6. The polarized-light splitting element 6P of the polarization beam splitter 6 reflects and analyzes the modulated beam (S-polarized beam) in the color-synthesized beam. The modulated beam reflected

10 by the polarized-light splitting element 6P exits the polarization beam splitter 6. The modulated beam exiting the polarization beam splitter 6 enters a projection lens 11. The projection lens 11 projects images generated on the color light valves 10B, 10R,

15 10G as a full-color image on a screen 12.

In the projection type display device according to the prior art, light is absorbed by glass materials constituting the polarization beam splitter 6, and the prisms 7, 8, 9 of the color

20 separating/synthesizing composite prism, a bonding agent for bonding the prisms to each other and an optical thin film for color-separating the incidence beams. With this light absorption, the polarization beam splitter 6, the prisms 7, 8, 9 get exothermic.

25 With this heat emission, volumes of the optical elements expand. Herein, the optical elements such as the polarization beam splitter 6 and the prisms 7,

8, 9 are mechanically fixed to a frame or the like.
Accordingly, stresses derived from the heat emission
occur in interiors of the optical elements. Then, a
polarized-light splitting characteristic declines due

5   to these stresses. This results in such a problem
that a contrast of the projected image decreases.

A relationship between the stresses derived
from the heat emission and configurations of the
light paths or the optical elements, will be

10   explained in greater detail.

Referring to FIG. 11, the beams converged on
the lens elements 3a, 3c of the second lens plate 3
that correspond to the outermost lens elements 2a, 2c
of the first lens plate 2 receiving the incidence of

15   the light source beams, form luminous points.
Outermost marginal rays i1, i2 of the beams emerging
from these luminous points travel through the
condenser lens 4 and the field lens 5. Then, the two
rays i1, i2 become the outermost marginal rays of the

20   beam entering the polarization beam splitter 6.

Further, the light source beam traveling via
the lens element 2b of the first lens plate 2 on an
optical axis I is converged as a luminous point on
the corresponding lens element 3b of the second lens

25   plate 3. The beam from this luminous point on the
second lens plate 3 becomes chief rays i0. The field
lens 5 collimates the chief rays i0 into

substantially parallel light rays. Then, the chief
rays collimated into substantially the parallel light
rays travel through the prisms 7, 8, 9 of the color
separating/synthesizing composite prism and the color
5   light valves 10B, 10R, 10G and are converged at an
aperture stop (unillustrated) of the projection lens
11.

A size of each of incidence surfaces of the
light valves 10B, 10R, 10G is 0.907 in., and a
10   surface dimension of the incidence surface is given
by 18.43 mm (width) X 13.82 mm (length). In FIG. 11
showing the schematic geometry, a long side of the
incidence surface of each of the light valves 10B,
10R, 10G is parallel with the sheet surface, while
15   the short side is vertical to the sheet surface.
This geometry will hereinafter be called a "lateral
layout".

FIG. 12A is a view showing a configuration in
section perpendicular to the light source beam
20   incidence surface 7a of the prism 7. The outermost
marginal ray i1 enters, from the side of the surface
7a, the vicinity of an acute-angled α portion formed
of the incidence surfaces 7a, 7b of the prism 7
taking substantially a shape of a triangular prism.
25   .   FIG. 12B is a view viewed from the side of the
surface 7a of the prism 7. FIG. 12C is a view viewed
from the side of the surface 7c of the prism 7. The

B-beam in the beam entering the surface 7a is reflected by the surface 7b coated with the dichroic film reflecting the B-beam. Next, the B-beam is totally reflected by the surface 7a and thereafter

5   exits the surface 7c. Therefore, as shown in FIG. 12B, an effective area 7d irradiated with the beam in the area of the surface 7a does not take a shape proportional to the configuration of the radiation element of the light valve and takes a shape enlarged

10   in the longitudinal direction. Note that an apex portion, having an angle of 54 degrees, of the prism 7 does not, as shown in FIG. 12A, substantially transmit the beam. Hence, this portion assumes a shape cut, wherein a width of 3 mm from the effective

15   portion of the illumination radiation is left.

       FIG. 12D is a view showing a contrast decline portion N1 appeared on the projected image. The decline of contrast, when the projected image is displayed in black, becomes more conspicuous because

20   of the contrast decline portion N1 becoming whitish.

       The inventor of the present application analyzed internal stresses due to thermal expansions caused by the incidence of the beam with respect to the prism 7 in the projection type display device

25   according to the prior art. An analysis model is calculated by use of a finite element method on the assumption that the beam with a uniform distribution

totally enters the incidence surface 7a of the prism
7 in FIG. 12A. FIG. 13 qualitatively depicts
directions and moments of the internal stresses
occurred in the prism 7 by use of double-arrow lines.

5   As obvious from FIG. 13, it proved that the stresses
concentrate on the acute-angled α portion of the
prism 7. Further, an absolute value of the stress is
large in the vicinity M of the center of the acute-
angled α portion in a direction of a height h. The

10   stress in the vicinity M of the center occurs in the
direction parallel to the height h of the prism 7.

       Moreover, the inventor of the present
application found out that the internal stresses
occur in the upper and lower surfaces 7e, 7f of the

15   prism so as to continuously link in the directions
parallel with the upper and lower surfaces 7e, 7f.

       Note that the thermal stresses, as in the prism
7, occur in the optical elements such as the
polarization beam splitter 6 and the prisms 8, 9. In

20   the polarization beam splitter 6 etc, however, the
number of passages of the beams through the same
portion within each optical element is counted "2" in
reciprocation, which is less than in the case of the
prism 7. A light quantity of the beam traveling

25   through the prisms 8, 9 decreases corresponding to a
quantity of the beam reflected by the prism surface
7b. Therefore, both an exothermic quantity based on

the light absorption and the thermal stress occurred
are smaller than in the prism 7. Accordingly, it is
apparent that the contrast of the projected image
declines due to mainly the stresses occurred in the

5   prism 7 exhibiting the maximum passage count of the
beams.

The prism 7 has a function of synthesizing and
analyzing the plurality of colors but has a large
ununiformity in the projected image if the problem of

10   the thermal stress rises, and exhibits a conspicuous
decline of contrast.

SUMMARY OF THE INVENTION

It is a primary object of the present invention,

15   which was devised in view of the problems described
above, to provide a projection type display device
capable of obtaining a projected image exhibiting no
ununiformity and a preferable contrast with a simple
construction.

20   To accomplish the above object, according to
one aspect of the present invention, a projection
type display device comprises an illumination optical
system for supplying an illumination radiation, a
polarization splitting/color separating optical

25   system for polarization-splitting and color-
separating beam from the illumination optical system,
reflection type light valves, each taking a

rectangular shape, for modulating the beam from the
polarization splitting/color separating optical
system in accordance with an image signal and letting
the modulated beam exit, a color synthesizing optical

5   system for color-synthesizing the beams from the
reflection type light valves, a light analyzing
optical system for analyzing the beam from the color
synthesizing optical system, and a projection optical
system for projecting on a predetermined surface an

10   image based on the image signal generated in the
reflection type light valves, wherein when the image
signal indicates black, the color synthesizing
optical system and the light valve are positioned so
that a color of a predetermined point in the vicinity

15   of an apex but inside of the apex of a rectangular
display area on the predetermined surface, becomes a
color of such a coordinate value that a distance of a
color in the position corresponding to the center of
the light valve is equal to or less than 0.09 from

20   the coordinate value in a u'v' space. Herein, the
u'v' space is defined as a coordinate space in a u'v'
chromaticity diagram. The u'v' chromaticity diagram
is the same as CIE1976UCS chromaticity diagram as
well as being a coordinate system close to a human

25   sensation to a color difference and created so that a
color difference sensed by human eyes is
substantially proportional to a difference between

coordinate values on the chromaticity diagram. The
projected image is recognized essentially by the
human eyes, and hence this coordinate system is
herein used as a basis for representing the colors.

5   Further, a distance of a certain point (ux, vx) from
central coordinates (uc, vc) is expressed by the
following formula (1):

$$\text{Distance} = \{(ux - uc)^2 + (vx - vc)^2\}^{1/2} \qquad (1)$$

In the projection type display device of the
10   present invention, when the image signal indicates
black, a color separating/synthesizing optical system
and the light valves are positioned so that the color
of the predetermined point in the vicinity of an apex
but inside of the apex of a rectangular display area
15   on the predetermined surface, becomes a color of such
a coordinate value that a distance of a color in the
position corresponding to the center of the light
valve is equal to or less than 0.04 from the
coordinate value in the u'v' space.

20   In the projection type display device according
to the present invention, it is preferable that the
reflection type light valve includes a reflection
type light valve for a blue beam and a reflection
type light valve for a long wavelength region, upon
25   which the beam in the longer wavelength region than
the blue beam is incident, the color synthesizing
system includes a first prism and a second prism, the

first prism receives an incidence of the beam from
the light valve for the long wavelength region and
lets the beam exit, and the second prism receives an
incidence of the beam from the light valve for the
5   blue beam, then receives an incidence of the beam
exiting the first prism, synthesizes the blue beam
entering the second prism with the beam in the long
wavelength region and lets the synthesized beam exit
toward the light analyzing optical system.

10   In the projection type display device according
to the present invention, it is preferable that the
color synthesizing optical system includes a prism,
the prism has a first surface totally reflecting the
beam from the reflection type light valve, and a
15   second surface receiving an incidence of the beam
after the beam from the light valve has been
reflected by a dichroic film, and the first surface
is flush with the second surface.

In the projection type display device according
20   to the present invention, it is preferable that the
prism of the synthesizing optical system has an apex
angle of 45 degrees or smaller.

In the projection type display device according
to the present invention, when the image signal
25   indicates black, the color synthesizing optical
system and light valves are positioned so that a
color of any one of points in the rectangular display

area on the predetermined surface, becomes a color of such a coordinate value that a distance of a color in a position corresponding to the center of the light valve is equal to or less than 0.09 from a coordinate

5   value in the u'v' space.

In the projection type display device according to the present invention, when the image signal indicates black, the color synthesizing optical system and light valves are positioned so that a

10   color of any one of points in a rectangular display area on the predetermined surface, becomes a color of such a coordinate value that a distance of a color in the position corresponding to the center of each light valve is equal to or less than 0.04 from the

15   coordinate value in the u'v' space.

In the projection type display device according to the present invention, the predetermined point is a point at which to divide, at a ratio of 9 to 1, a distance between the position corresponding to the

20   center of each light valve in the rectangular display area on the predetermined surface and the apex of the rectangular display area.

BRIEF DESCRIPTION OF THE DRAWINGS

25   FIG. 1 is an explanatory view showing a basic construction of a projection type display device in a first embodiment of the present invention;

FIG. 2 is a view schematically showing a configuration of a modified example of the first embodiment;

FIGS. 3A through 3C are views each showing a configuration of a prism in the modified example of the first embodiment;

FIGS. 4A and 4B are diagrams showing measuring points;

FIGS. 5A and 5B are graphs showing color coordinates of a projected image in a modified example of the first embodiment;

FIGS. 6A and 6B are graphs showing color coordinates of a projected image according to the prior art;

FIGS. 7A through 7C are views each showing a configuration of the prism in a second embodiment;

FIG. 8 is a view schematically showing a configuration in a third embodiment;

FIGS. 9A through 9C are views each showing a prism in the third embodiment;

FIGS. 10A through 10C are views each showing a prism in a fourth embodiment;

FIG. 11 is an explanatory view showing a basic configuration of a projection type display device in the prior art;

FIGS. 12A through 12D are views each showing a configuration of a prism in the prior art; and

FIG. 13 is a view showing stresses occurred in the prism.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

5   Embodiments of the present invention will hereinafter be described with reference to the accompanying drawings.

(First Embodiment)

FIG. 1 is a view schematically showing a

10   configuration of a projection type display device in a first embodiment of the present invention. A light source 101 constructed of a lamp L and a parabolic mirror PM having a concave surface, emits a substantially parallel beam as light source beam.

15   The light source beam from the light source 101 enters a fly's eye integrator FE. The fly's eye integrator FE is constructed of a first lens plate 102 having a plurality of first lens elements 102a, and a second lens plate 103 having a plurality of

20   second lens elements 103a corresponding to the first lens elements 102a. Herein, the second element elements 103a are provided in focal positions of the first lens elements 102a. The light incident upon the first lens plate 102 is split into a plurality of

25   beams defined by external lens shapes of the first lens elements 102a. The external shapes of the first lens elements 102a are analogous to shapes into which

light receiving surface of light valves 110B, 110R,
110G defined as radiation receiving members are
proportionally reduced. Each of light receiving
surfaces of the light valves 110B, 110R, 110G takes a
5   rectangular shape. Therefore, the first lens element
102a also takes a rectangular shape. Then, the beams
entering the first element elements 102a of the first
lens plate 102 converge on the second lens elements
103a of the second lens plate 103, thus forming
10   luminous points.

With such a configuration, the fly's eye
integrator FE splits the beam emitted from the light
source 101. The thus split light beams are
overlapped on the light receiving surfaces of the
15   light valves 110B, 110R, 110G defined as the
radiation receiving surfaces. A uniformity of
illuminance of the illumination radiation can be
thereby enhanced.

Next, the beams emitted from the fly's eye
20   integrator FE travel through a condenser lens 104 and
a field lens 105 and enter a polarization beam
splitter 106.

The polarization beam splitter 106 has a
polarized light splitting element 106P. The
25   polarized light splitting element 106P separates the
light source beam from the light source 101 into P-
polarized beam penetrating the polarized light

splitting element 106P and S-polarized beam reflected by this splitting element 106P. The penetrated P-polarized beam exit the polarization beam splitter 106 and enters a color separating/synthesizing prism constructed of prisms 107,108, 109 and a plurality of dichroic films coated on predetermined surfaces of these prisms. The S-polarized beam reflected from the polarized light splitting element 106P, after a light path of the S-polarized beam has been deflected at 90 degrees, travel forward and are then discarded.

Given next is an explanation of a structure of the color separating/synthesizing prism that color-separates the light beam into an R-beam, a G-beam and a B-beam. As described above, the color separating/synthesizing prism is constructed of the three pieces of prisms 107, 108 and 109.

To start with, the prism 107 for extracting the B-beam component out of the light source beam, will be explained.

The prism 107 has a first surface 107a, a second surface 107b and a third surface 107c. The first surface 107a admits an incidence of the light source beam. The second surface 107b has a B-beam reflection dichroic film DB that reflects the B-beam but transmits the R- and G-beams. The third surface 107c lets the B-beam exit, which has been reflected from the second surface 107b and next totally

reflected by the first surface 107a. With this
structure, the prism 107 is capable of extracting the
B-beam component in the beam emitted from the light
source 101.

5   The B-beam having exited the third surface 107c
enters the light valve 110B for the B-beam.

Next, the prism 108 for extracting the R-beam
component out of the light source beam, will be
explained.

10   The prism 108 is disposed with an air gap from
the second surface 107b of the prism 107. The prism
108 has a first surface 108a, a second surface 108b
and a third surface 108c. The first surface 108a
admits an incidence of the beam penetrating the

15   second surface 107b of the prism 107. The second
surface 108b has an R-beam reflection dichroic film
DR that reflects the R-beam but transmits the G-beam.
The third surface 108c lets the R-beam exit, which
has been reflected from the second surface 108b and

20   next totally reflected by the first surface 108a.
With this structure, the prism 108 is capable of
extracting the R-beam component in the beam emitted
from the light source 101.

The R-beam having exited the third surface 108c

25   enters the light valve 110R for the R-beam.

Next, the prism 109 for extracting the G-beam
component out of the light source beam, will be

described.

The prism 109 is provided in a way that fixes its first surface 109a to the second surface 108b of the prism 108 by a bonding agent.

5   The prism 109 has a first surface 109a, a second surface 109b and a third surface 109c. The first surface 109a admits an incidence of the beam penetrating the second surface 108b of the prism 108. The second surface 109b totally reflects the G-beam.

10   The third surface 109c lets the G-beam exit, which has been totally reflected from the second surface 109b. With this structure, the prism 109 is capable of extracting the G-beam component in the beam emitted from the light source 101.

15   The G-beam having exited the third surface 109c enters the light valve 110G for the G-beam.

Next, a structure of the reflection type light valve will briefly described. The reflection type light valve used in the first embodiment is

20   classified as an electrically writable reflection light valve taking a rectangular shape. A size of an incidence surface of each light valve is the same as in the prior art described above and is therefore 0.907 in., and a surface dimension of the incidence

25   surface is 18.43 mm (width) X 13.82 mm (length). The light valves are disposed lengthwise in the first embodiment and a second embodiment but crosswise in

third and fourth embodiment which will be discussed,
later on. The electrically writable reflection light
valve is constructed of a non-linear element such as
a TFT (Thin Film Transistor) provided per pixel on a
5   silicon wafer substrate, a reflection mirror element
connected to an output portion of this non-linear
element, and a liquid crystal layer disposed between
the mirror element and a transparent electrode. Then,
with switching of the TFT selected by a color signal
10   of each color beam, an array of liquid crystal
molecules in the liquid crystal layer can be changed
for every pixel. Herein, the liquid crystal layer
functions as a wavelength plate with respect to the
P-polarized beam incident on the position
15   corresponding to the pixel selected. Therefore, a
polarizing direction of the incident beam is changed
into S-polarized beam, and thus the beam is reflected
as a modulated beam and then exits. On the other
hand, the P-polarized beam incident on the position
20   corresponding to a non-selected portion is reflected
as a non-modulated beam in a way that keeps the state
of the P-polarized beam, and then exits.

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The beams modulated by the light valves 110b,
110R, 110G for the respective color are again
25   incident as the S-polarized beams upon the color
separating/synthesizing prism.

The color separating/synthesizing prism color-

synthesizes the beams reflected from the light valves
110B, 110R, 110G. The color-synthesized beam is
analyzed by the polarized light splitting element
106P of the polarization beam splitter 106. Then,

5   only the S-polarized beam component as the beam
modulated by the light valve enters a projection lens
111. The projection lens 111 projects images of the
R-, G- and B-color light valves as a full-color image
on a screen 122. Note that the P-polarized beam

10   component as the non-modulated beam travels straight
through the polarized light splitting element 106P of
the polarization beam splitter 106, then exits on the
side of the light source 101 and is discarded.

Herein, the B-beam is easily absorbed by the

15   optical member. Hence, the scheme is that the B-beam
is color-synthesized finally.

To give a further explanation of the above
prism 107, the prism 107 totally reflects the beam
from the reflection type light valve 110B at its

20   first surface 107a, and subsequently this reflected
beam, after being reflected by the dichroic film DB,
enters the first surface 107a back.

Next, glass materials of the polarization beam
splitter 106 and of the prisms 107, 108, 109

25   configuring the color separating/synthesizing prism,
will be explained. If the modulated beams modulated
by the light valves 110B, 110R, 110G change in their

polarizing states in the process of traveling through the polarization beam splitter 106 and the respective prisms 107, 108, 109, a contrast of the analyzed beams declines. It is therefore desirable that these

5   glass materials do not change the polarizing states of the polarized beams traveling through the prisms. Hence, it is required that the glass material exhibiting a small absolute value of <u>an optical elastic modulus</u> (which will hereinafter be called a

a photoelastic constant

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10   "C-value") be used. In view of this requirement, the first embodiment involves the use of the glass material exhibiting the small absolute value of C-value having a composition shown in the following Table 1. This glass material has the absolute value

15   of C-value, which is equal to or less than 5×10^{-9} cm^2/N in a region where the wavelength ranges from 400 nm to 700 nm. This glass material is one of the glass materials exhibiting an excellent characteristic with the minimum C-value.

20   (Table 1)

Composition	Percentage Content (WT%)
SiO_2	24.4
Na_2O	0.9
K_2O	0.9
PbO	73.5
As_2O_3	-
Sb_2O_3	0.3

Note that the first embodiment has the scheme
in which the P-polarized beams, as shown in the
discussion given above, enter the light valves, and
the S-polarized beams are reflected as the modulated

5   beams by the polarization beam splitter and then
analyzed. Without being limited to this scheme,
however, another scheme may also be taken, wherein
the S-polarized beams enter the light valves, and the
P-polarized beams penetrate as the modulated beams

10   the polarization beam splitter and are then analyzed.
Next, the prism 107 will be described. As can
be seen in FIG. 1, the prism 107 in the first
embodiment assumes a shape with its acute-angled
portion cut off. This configuration will be

15   explained in greater detail with reference to FIGS.
13 and 12D. FIG. 13 shows a stress distribution of
the prism 7 in the prior art. FIG. 12D shows a
decline of contrast of a projected image.
As described above, the stress occurs in the

20   prism in the prior art as shown in FIG. 13.
Supposing herein that a birefringence occurs due to
the internal stress in a central area of a front side
end having an acute angle α, the decline of contrast
of the projected image shown in FIG. 12D is to occur

25   in the vicinity of a central area N2 of a right side
end surface. The actual decline of contrast, however,
occurs in an area N1 shown in FIG. 12D.

The inventor of the present application concentrates his attentions on such a point that the polarized beam (P-polarized beam) passing via the polarization beam splitter 6 travels through within

5   the prism 7 in the projection type display device according to the prior art. Referring to FIG. 13, a direction of oscillations of the polarized beam (P-polarized beam) is substantially right-angled to the direction (parallel to the sheet surface) of the

10   internal stress in the vicinity of the area M of the acute-angled α front side end of the prism 7. Therefore, almost no phase difference occurs in the polarized beam passing through the prism 7. As a result, the direction of oscillations of the

15   transmitted beam remains as it is.

By contrast, a continuous internal stress into which the front side end stress and a stress occurred on an upper surface 7e or a lower surface 7f are synthesized, occurs in the vicinity of an upper side

20   end area U or a lower side end area L of the prism 7. An absolute value of magnitude of this continuous internal stress is small. The continuous internal stress in the vicinity of the upper side end area U or the lower side end area L occurs in the direction

25   substantially at 45 degrees to the direction of oscillations of the incident polarized beam. Hence, a phase difference is easy to occur in the polarized

beam passing through the prism 7. As a result, there
changes the direction of oscillations of the
polarized beam traveling via the vicinity of the
upper side end area U or the lower side end area L.

5   For the reason elucidated above, according to
the first embodiment, the portion vicinal to the apex
having the acute angle α is cut off. With this
configuration, the polarized beam passing through the
prism 107 can reduce the influence of the stress
10   occurred in the upper side end area U or the lower
side end area L of the acute-angled α front side end
portion. It is therefore possible to keep the state
of oscillation coupling of the polarized beam
traveling through within the prism 107. This results
15   in exhibiting such an effect that the projected image
having a preferable contract can be obtained.

       FIG. 2 is a perspective view schematically
showing a configuration of the projection type
display device in a modified example of the first
20   embodiment. Referring to FIG. 2, for simplifying the
illustration, the fly's eye integrator FE, the field
lens 104 and the condenser lens 105 are omitted.
Further, the same components as those in the first
embodiment are marked with the same numerals, and the
25   repetitive explanations are omitted. As shown in FIG.
2, the configuration is that side surfaces 107e, 107f
through which none of the beams from the prism 107

pass, are parallel to a long side LL of a rectangular display area for the projected image.

This modified example takes a configuration in which the prism 7 is extended in a direction of its height h. With this configuration taken, it is feasible to avoid the stress from affecting the transmitted beams, this stress occurring in the vicinity of the upper side end area U or the lower side end area L shown in FIG. 13.

FIG. 3A is a view showing a configuration in section perpendicular to an incidence surface 107a, on which the light source beam is incident, of the prism 107. FIG. 3B is a view as viewed from the side of the surface 107a. FIG. 3C is a view as viewed from the side of the surface 107c. The height h is 39 mm which is higher than the prism in the prior art, however, other sizes are the same as those in the prior art. Note that glass materials used herein are the same as those in the prior art.

FIG. 3B shows an effective illumination area 107d. Referring to FIG. 12B in the prior art, a width around the non-illumination area 7d is 2.7 mm. By contrast, according to this embodiment, the width is 6.2 mm. Further, according to the prior art, a ratio of a length of the effective illumination area 7d in the direction of the height h of the prism to the height of the prism, is 1 : 1.203. By contrast,

according to this embodiment, this ratio is 1 : 1.466.

FIG. 3B also shows a contrast decline area N1 of the projected image on the surface 107a of the prism 107. As obvious from FIG. 3B, the contrast

5   decline area N1 is not projected on the screen 112. As a result, it is possible to exhibit the effect in which the projected image having the preferable contrast can be obtained.

Next, a procedure of measuring the contrast of

10   the projected image in this embodiment will be explained. To begin with, as shown in FIG. 4A, the rectangular display area (image projection area) defined as a predetermined surface of the screen 112 is segmented into nine segments. Then, colors are

15   measured when the image signal indicates black at totally 13 points including measuring points Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9 at the centers of the respective segments and measuring points Nos. 10, 11, 12, 13 existing in the vicinity of the four apices of

20   the rectangular display area but inside of these apices.

FIG. 4B shows position coordinates of the measuring points Nos. 1 through 13. The origin (0, 0) is set at the center (the position corresponding

25   to the measuring point No. 5) of the rectangular display area. Herein, the measuring point No. 12 is a point at which to divide, at a ratio of A:B = 9:1,

a distance between the apex of the rectangular
display area and the measuring point No. 5,
corresponding to the center of each of the light
valves 110B, 110R, 110G, in the rectangular display
5   area of the screen 112.

       FIG. 5A is a graph representing, based on a
u'v' coordinate system (CIE1976UCS chromaticity
diagram), the colors of the positions of the
measuring points Nos. 1 though 13 in the rectangular
10   display area (the image projection area) of the
screen 112 that is defined as the predetermined
surface when the image signal indicates black in the
embodiment shown in FIGS. 3A through 3C. Further,
FIG. 5B is an enlarged diagram showing measured
15   values in FIG. 5A.   Moreover, the following Table 2
shows the measured values at the respective measuring
points and distances from the measuring point 5.
(Table 2)

Measuring Point Nos.	u'	v'	Distances from Measuring Point 5
1	0.183322	0.431082	0.00961
2	0.184486	0.426101	0.004497
3	0.182195	0.430124	0.008997
4	0.184922	0.419275	0.002429
5	0.18529	0.421676	0

6		0.184851	0.428423	0.006761
7		0.182635	0.397455	0.024366
8		0.185359	0.413812	0.007864
9		0.188411	0.420725	0.003263
10		0.18144	0.428497	0.007833
11		0.185904	0.43667	0.015007
12		0.182229	0.394767	0.027083
13		0.189905	0.424109	0.005217

According to this embodiment, when the image
signal indicates black, the color synthesizing
optical system 107 and the light valve 110B are
positioned so that the color at the measuring point
No 12 existing in the vicinity of the apex but inside
the apex of the rectangular display area of the
screen 112 that is defined as the predetermined
surface, becomes such a coordinate value color that
the distance from the u'v' space coordinate value of
the color at the measuring point No. 5 corresponding
to the center of the light valve 110B, is equal to a
smaller than 0.027 at the maximum.

Further, according to this embodiment, when the
image signal indicates black and even if at any one
of the measuring points Nos. 1 through 13, the color
synthesizing optical system 107 and the light valve
110B are positioned so that the color at that
measuring point becomes such a coordinate value color
that the distance from the u'v' space coordinate

value of the color at the measuring point No. 5

corresponding to the center of the light valve 110B,

is equal to a smaller than 0.09 and preferably 0.04.

If the distance is 0.04 or less, the human eyes are

5 hard to detect a ununiformity in chromaticity of

black. As a result, there is exhibited an effect in

which the projected image with a preferable contrast

can be displayed.

Further, for a comparison with this embodiment,

10 FIGS. 6A and 6B show results of the same color

measurements in the projection type display device

using the prism 7 in the prior art illustrated in

FIGS. 12A through 12C. Table 3 shows the measured

values thereof and the distances from the measuring

15 point 5.

(Table 3)

Measuring Point Nos.	u'	v'	Distances from Measuring Point 5
1	0.189894	0.459125	0.005802
2	0.18797	0.468045	0.005215
3	0.190537	0.461797	0.003086
4	0.19368	0.440367	0.024282
5	0.191868	0.464581	0
6	0.191745	0.456289	0.008293
7	0.204545	0.400568	0.065256

8	0.197523	0.447439	0.018051
9	0.203568	0.432844	0.033825
10	0.187097	0.457258	0.00874
11	0.184864	0.470378	0.01728
12	0.203474	0.361042	0.104187
13	0.202343	0.426518	0.039478

According to the prior art (FIGS. 11, 12A, 12B and 12C), when the image signal indicates black, the color synthesizing optical system 7 and the light valve 10B are positioned so that the color at the measuring point No 12 existing in the vicinity of the apex but inside the apex of the rectangular display area of the screen 12 that is defined as the predetermined surface, becomes such a coordinate value color that the distance from the u'v' space coordinate value of the color at the measuring point No. 5 corresponding to the center of each of the light valves 10B, 10R, 10G is 0.104 at the maximum.

It is obvious that the distance 0.027 described above in this embodiment is more improved than the distance 0.104 in the prior art.

(Second Embodiment)

FIGS. 7A, 7B and 7C are views each showing the prism 107 of the projection type display device in a second embodiment. The basic configuration of the projection type display device is the same as that in the first embodiment, wherein the same components are

marked with the same numerals, and the repetitive
explanations are omitted.

     FIG. 7A is the view showing a configuration in
section perpendicular to the light source beam

5   incidence surface 107a of the prism 107. FIG. 7B is
the view viewed from the side of the surface 107a.
FIG. 7C is the view viewed from the surface of the
surface 107c. The configuration in the second
embodiment is that the beams do not penetrate areas

10   proximal to the portion having the most acute angle α.
Therefore, a length of the surface 107a in the
longitudinal direction is larger than that in the
prism in the prior art shown in FIG. 12A. Hence, as
apparent from FIG. 7B, positions of an incidence

15   optical axis I and outermost marginal rays i1, i2
shift rightward from the center on the surface 107a.
Herein, in the prism in the prior art shown in FIG.
12A, the portion of an internal angle of 54 degrees
is cut off. By contrast, according to the second

20   embodiment, the incidence beams shift rightward and
therefore penetrate the portion of the internal angle
of 54 degrees. This portion is not therefore cut off,
and the prism assuming the triangular shape is used
as it is.

25   Further, with respect to the effective
illumination area 107d on the incidence surface 107a
of the prism 107, the non-illumination width is set

to 3 mm in the prism according to the prior art shown in FIG. 12B and, by contrast, set to 14 mm in the second embodiment.

Note that other configurations and the height h of the prism 107 are substantially the same as those in the prism according to the prior art illustrated in FIGS. 12A through 12C.

FIG. 7B also shows the contrast decline area N1 of the projected image on the surface 107a of the prism 107. As obvious from FIG. 7B, the contrast decline area N1 is not projected on the screen 112. As a consequence, there is acquired the effect in which the projected image having the preferable contrast can be obtained.

(Third Embodiment)

FIG. 8 is a perspective view schematically showing a configuration of the projection type display device in a third embodiment. Referring to FIG. 8, for simplifying the illustration, the fly's eye integrator FE, the field lens 104 and the condenser lens 105 are omitted. Further, the same components as those in the first embodiment are marked with the same numerals, and the repetitive explanations are omitted. In the third embodiment, the direction in which the light valves 110R, 110G, 110B is different from that in the first embodiment. As illustrated in FIG. 8, the geometry is that the

side surfaces 107e, 107f each receiving no transmission of the beams from the prism 107 are substantially orthogonal to a long side LL of the rectangular display area for the projected image.

5 Hereinafter this geometry is called a (vertical layout). Note that as the vertical layout is adopted, the shapes of primarily the polarization beam splitter 106 and the light valves 110B, 110R, 110G and also the fly's eye integrator FE, are changed.

10 FIG. 9A is a view showing a configuration in section perpendicular to the light source beam incidence surface 107a of the prism 107. FIG. 9B is a view as viewed from the side of the surface 107a. FIG. 9C is a view as viewed from the side of the

15 surface 107c. According to the third embodiment, the height h is of the surface 107a of the prism 107 is higher than in the prism according to the prior art. Then, the non-illumination width in the third embodiment is 7.35 mm from the upper side end.

20 FIG. 9B also shows the contrast decline area N1 of the projected image on the surface 107a of the prism 107. As obvious from FIG. 9B, the contrast decline area N1 is not projected on the screen 112. As a consequence, there is acquired the effect in

25 which the projected image having the preferable contrast can be obtained.

(Fourth Embodiment)

The projection type display device in a fourth embodiment adopts the same vertical layout as that in the third embodiment. Further, the same components as those in the first embodiment are marked with the
5   same numerals, and the repetitive explanations are omitted.

FIG. 10A is a view showing a configuration in section perpendicular to the light source beam incidence surface 107a of the prism 107. FIG. 10B is
10   a view as viewed from the side of the surface 107a. FIG. 10C is a view as viewed from the side of the surface 107c. According to the fourth embodiment, the length of the surface 107a of the prism 107 in the longitudinal direction is larger than in the
15   prism according to the prior art shown in FIGS. 12A through 12C. In the fourth embodiment, the non-illumination width is 14 mm from the left side end.

FIG. 10B also shows the contrast decline area N1 of the projected image on the surface 107a of the
20   prism 107. As obvious from FIG. 10B, the contrast decline area N1 is not projected on the screen 112. As a consequence, there is acquired the effect in which the projected image having the preferable contrast can be obtained.

25   As discussed above, according to the present invention, it is feasible to provide the projection type display device capable of obtaining the

projected image exhibiting no ununiformity but the preferable contrast with the simple configuration.